

10/529,376

according to the present invention. Here, when a direction of polarization of the laser beam is set in a direction Y, a periodic structure  $8_x$  oriented in a direction X is obtained as shown in Fig. 15[[A]](a), while setting the direction of polarization of the laser beam in the direction X results in formation of a periodic structure  $8_y$  oriented in a direction Y, as shown in Fig. 15[[B]](b).--

*20 34*  
Please amend the paragraph beginning at line ~~1~~<sup>20</sup> of page ~~35~~<sup>34</sup> as follows:

*EMQ*  
11/18/10

--Also, changing a direction of polarization of the laser beam allows changing a direction of the periodic structure. Based on this, in the case where, after once forming a periodic structure  $8_x$  oriented in one direction as shown in Fig. 15[[A]](a) by irradiating a laser beam near an ablation threshold and executing an overlapped scanning on the irradiated region in one direction, a relative angle between the material surface and the direction of polarization of the laser beam is changed, followed by irradiation of the laser beam near the ablation threshold and overlapped scanning on the irradiated region over the periodic structure already formed so as to form a periodic structure  $8_y$  in a different direction, a composite grating structure  $8_z$  overlapped in a different direction can be formed.--

*8*  
Please amend the paragraph beginning at line ~~14~~<sup>8</sup> of page 35 as follows:

*EMQ*  
11/18/10

--Accordingly, changing the relative angle between the material surface and the direction of polarization of the laser beam by 90 degrees as shown in Fig. 15[[C]](c), when forming the latter periodic structure, results in formation of a check patterned periodic structure  $8_z$ , and changing the relative angle between the material surface and the direction of polarization of the laser beam by a desired angle other than 90 degrees leads to formation of a bias check patterned periodic structure.--

*16*  
Please amend the paragraph beginning at line ~~22~~<sup>16</sup> of page 35 as follows:

*EMQ*  
11/18/10

--Referring now to Fig. 15[[D]](d), in the case where, after once forming a periodic structure  $8_x$  in one direction by irradiating a laser beam near an ablation threshold and executing an overlapped scanning on the irradiated region in one direction, a relative angle

between the material surface and the direction of polarization of the laser beam is changed, followed by irradiation of the laser beam near the ablation threshold on a region adjacent to or spaced from the periodic structure  $8_x$  already formed and overlapped scanning on the newly irradiated region, another periodic structure  $8_y$  can be formed in a different direction in the region adjacent to or spaced from the first formed periodic structure  $8_x$ . Accordingly, changing the relative angle between the material surface and the direction of polarization of the laser beam by 90 degrees, when forming the latter periodic structure, results in formation of a periodic structure  $8_x$  in an X direction and the other  $8_y$  in a Y direction, disposed in a mixed layout, and changing the relative angle between the material surface and the direction of polarization of the laser beam by a desired angle other than 90 degrees leads to formation of the periodic structures oriented in different directions and disposed in a mixed layout.--

Please amend the paragraph beginning at line 19 of page 36 as follows:

*CD  
11/18/10*

—Also as already stated, based on the fact that changing the direction of polarization of the laser beam leads to a change in the orientation of the periodic structure, a grating structure overlapped in different directions as shown in Fig. 15[[ $\Theta$ ]](c) can be formed through one process utilizing a periodic structure forming apparatus 40 as shown in Fig. 16. The periodic structure forming apparatus 40 of Fig. 16 emits a laser beam  $L_0$  generated by a titanium-sapphire laser generator 41, so that the laser beam  $L_0$  is totally reflected by a mirror 42, and split by a half mirror 43 into a reflected laser beam  $L_1$  and a transmitted laser beam  $L_2$ . Then the reflected laser beam  $L_1$  is totally reflected by mirrors 44, 45, so as to produce an optical delay 46 on the transmitted laser beam  $L_2$ . This optical delay 46 includes mirrors 47, 48. Laser beams  $L_3$ ,  $L_4$  produced by polarizing the laser beams  $L_1$ ,  $L_2$  with polarizer 49, 50 are provided to a half mirror 51, so that the half mirror 51 merges the polarized laser beams  $L_3$ ,  $L_4$  and irradiates through a lens 52 to a surface of a material 54 set on an X-Y table 53. In this way, the laser beams  $L_3$ ,  $L_4$  near the ablation threshold having a plurality of pulses and different directions of polarization can be irradiated to the surface of the material 54 at a determined time interval. Then executing an overlapped scanning over the irradiated region results in spontaneous and simultaneous formation of a periodic structure  $8_z$  overlapped in different directions as shown in Fig. 15[[ $\Theta$ ]](c).--

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ED  
11/18/10

Please amend the paragraph beginning at line 19 of page 37 as follows:

--Accordingly, for example, irradiating the laser beams L<sub>3</sub>, L<sub>4</sub> near the ablation threshold having a plurality of pulses and directions of polarization that are different by 90 degrees at a predetermined time interval, and executing an overlapped scanning over the irradiated region, results in spontaneous and simultaneous formation of a check patterned periodic structure 8<sub>Z</sub> as shown in Fig. 15[[E]](c), in which the periodic structure 8<sub>X</sub> oriented in an X direction and the periodic structure 8<sub>Y</sub> oriented in a Y direction which is orthogonal to the X direction are overlapping. Also, irradiating laser beams near an ablation threshold having a plurality of pulses and directions of polarization that are different by a desired angle other than 90 degrees at a predetermined time interval, and executing an overlapped scanning over the irradiated region, results in spontaneous and simultaneous formation of a bias check patterned grating structure intersecting in the desired angle other than 90 degrees.--

Please amend the paragraph beginning at line 19 of page 40 as follows:

--The disc-shaped test pieces are made of an ultra-hard alloy, on which various ring-shaped periodic structures have been formed as shown in Figs. 18[[A]](a) to 18[[D]](d). Fig. 18[[A]](a) shows a radial periodic structure, Fig. 18[[B]](b) shows a concentric circle pattern radial periodic structure, Fig. 18[[C]](c) shows a first spiral periodic structure, and Fig. 18[[D]](d) shows a second spiral periodic structure. The first spiral periodic structure of Fig. 18[[C]](c) and the second spiral periodic structure of Fig. 18[[D]](d) are different in the direction (angle) of the spiral pattern.--

Please amend the paragraph beginning at line 8 of page 43 as follows:

--Figs. 20[[A]](a) to 20D are line graphs showing a sliding test result in which the fixed test pieces having the mirror surface (20[[A]](a)), a periodic structure of the radial pattern (20[[B]](b)), a periodic structure of the concentric circle pattern (20[[C]](c)) and a periodic structure of the first spiral pattern (20[[D]](d)) were respectively used.

In the case of the test piece with the mirror surface of Fig. 20[[A]](a), the friction coefficient sharply increased immediately upon starting the sliding test. With respect to the test piece having the radial pattern periodic structure of Fig. 20[[B]](b), the friction

coefficient significantly decreased in comparison with the test piece with the mirror surface. With respect to the test piece having the concentric circle pattern periodic structure as Fig. 20[[E]](c), a visible fluid lubrication region has not been observed. In the case of the first spiral pattern periodic structure as Fig. 20[[D]](d), an intermediate characteristic between the radial pattern periodic structure and the concentric circle periodic structure has been observed, in the aspects of the fluid lubrication region and conformability in mixed lubrication. With respect to the test piece with the second spiral periodic structure, since the pattern serves as a pump to discharge the pure water from a central portion toward a peripheral portion because of the sliding motion, the friction coefficient suddenly increased up to higher than 0.5 once the pure water was completely discharged.--

*J*  
Please amend the paragraph beginning at line 9 of page 44 as follows:

*GD*  
10/18/10

--For evaluating discharging capability of worn powder, the load was increased to 100N, which is ten times as great as the load of an ordinary test, under which traces of wear were formed on the periodic structures, and observation thereof was performed. Fig. 21[[A]](a) shows a state of the radial pattern periodic structure, and Fig. 21[[B]](b) that of the concentric circle periodic structure. While the radial pattern periodic structure has been fully filled with the worn powder, grooves of the concentric circle periodic structure still remain uncovered with the worn powder, though scale-shaped worn particles are formed on the periodic structure.

Figs. 22[[A]](a) and 22[[B]](b) show a state of the periodic structure of the same test pieces as Figs. 21[[A]](a) and 21[[B]](b), but at a portion where the trace of wear is not produced. On the radial pattern periodic structure of Fig. 22[[A]](a) not much worn powder is observed, while a multitude of worn powders of approx. 100 nm is stuck on the concentric circle periodic structure of Fig. 22[[B]](b). In view of this, it is understood that the worn waste has barely moved from where it was produced in the radial pattern periodic structure, while the worn powder is discharged with the fluid by the grooves on the concentric circle periodic structure.--